NASA SBIR/STTR Technologies

H6.02-9737 - Radiation-Hardened Memristor-based Memory for Extreme Environments

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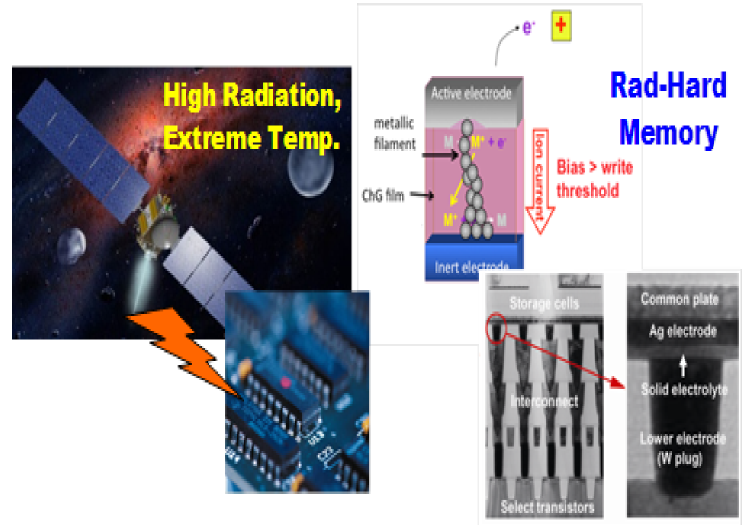
Identification and Significance of Innovation

- NASA missions need electronics that can survive and operate over wide temperature range and high radiation levels.
- Memristor (memory-resistor) is a promising technology for next generation of radiation-hardened, non-volatile memory (NVM), offering highly-desirable combination of density, access speed, and low power. Its radiation-hardness makes it a prime candidate for space applications.
- INNOVATIONS: a) Detailed experimental and simulation based characterization of memristor technologies, based on both chalcogenide-glass (ChG) and transition-metal-oxide (TMO, e.g. TiO2), for extreme temperatures of deep space; b) New physics-based memristor models & design tools valid at temperatures ranging from -230 deg C to +130 deg C. c) PRODUCT: after Phase II, demonstration of the world's first radiation-hardened, wide-temperature, memristor-based, non-volatile memory significantly outperforming traditional RHBD memories.

Estimated TRL at beginning and end of contract: (Begin: 3 End: 4)



Technical Objectives and Work Plan

OBJECTIVES: * Evaluate candidate memristor technologies (ChG and TMO) for radiation hardness and wide temperature performance. * Develop relevant models & design tools for memristor devices/circuits in space. * Develop and commercialize a radiation-hardened wide-temperature non-volatile memory.
WORK PLAN: CFDRC with Arizona State University (Dr. Hugh Barnaby) propose the following:
In Phase I: 1) Fabricate state-of-the-art ChG-based memristors; 2) Examine their low temperature performance via thermal experiments; 3) Add new models to CFDRC's NanoTCAD Mixed-Mode simulator for accurate physics-based simulation of memristors. The Phase I effort will evaluate suitability of ChG memristors for extreme temperature applications.
In Phase II: 1) Perform wide-temperature investigation of the competing transition-metal-oxide (TMO) memristor technology; 2) For both ChG and TMO, perform irradiation testing and down-select the technology with the best extreme environment (radiation + temperature) performance; 3) Subsequently, generate wide-temperature, radiation-enabled, device physics and compact models for the memristors; 4) Develop designs for memristor-based NVM, and perform mixed-mode simulations to determine their radiation and thermal response; 5) Use these results to develop an NVM prototype that will be tested and demonstrated for NASA space applications.

NASA Applications

The proposed innovation addresses the needs outlined in OCT Technology Area TA11: Modeling, Simulation, Information Technology and Processing Roadmap, in particular, for Computing (Flight Computing), which requires ultra-reliable, radiation-hardened platforms. The developed radiation-hardened, wide-temperature-stable non-volatile memory will immediately benefit exploration flight projects, robotic precursors, and technology demonstrators that are designed to operate beyond low-earth orbit (LEO).

Non-NASA Applications

Novel rad-hard non-volatile memory, threshold logic, reconfigurable architectures for space applications, such as broadband communication, surveillance, image storage and processing, for future DoD and commercial space systems. The new physics-based modeling & simulation tools will enable fast, reliable, and more accurate design of future memristor-based circuits.

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